Device for managing an electrical power failure in, in particular, a yarn transformation textile machine

The present invention relates to the technical field of textile machinery, especially machinery for converting yarn.

More especially, the invention relates to managing transient phases, particularly stoppages, in the event of failures of circuits in machinery for transforming moving textile yarns.

The invention has an especially advantageous application in cases where textile machinery has, firstly, means making it possible to advance the yarn such as cylinders that cooperate with pinch rollers, capstans, yarn guides or other devices and, secondly, means of processing yarns based on the principle of imparting rotation to said yarns, for example twisting them together or winding the yarns together.

Regardless of the technical solutions used, it is apparent, in a manner that is perfectly familiar to those skilled in the art, that yarn transformation processes are characterized by speed ratios between the devices intended to advance the yarn and those intended to produce torsion or other effects. For example, in the case of single twisting which involves winding off yarn from a reel that rotates around its own axis, the yarn is twisted against itself when it passes from the reel to a fixed support. If the yarn is wound off at a speed V (expressed in m/minute), this reel rotates around its own axis at a rotation speed N (expressed in r.p.m.), and the yarn thus processed is subjected to torsion $T = N/V$ expressed in r.p.m.

In the case of double twisting which involves winding off yarn from a fixed reel and running it into a rotating spindle, the hollow shaft of which is

placed in the centre of the reel, and then rotating it around said fixed reel, the yarn is subjected, as it travels from the fixed support to the rotating shaft, to twisting against itself and then, as it travels from the rotating shaft to the fixed support, to second twisting against itself in addition to the initial twisting. In this case, if the yarn is wound off at a speed V (expressed in m/minute) and the spindle rotates around its own axis at a rotation speed N expressed in r.p.m., the yarn thus processed is subjected to torsion $T = 2N/V$ expressed in r.p.m.

These means of twisting (torsion, cabling, reaming, etc.) are generally supplemented by devices intended to advance the yarn by transporting it with or without slippage. The relative speeds of these various devices make it possible to monitor the tension in yarns and obtain drafting or, on the contrary, relaxation.

Each device can be controlled by group or individual drive motors, for example synchronous motors controlled by frequency converters or changers. Synchronization of devices, and hence speed ratios, is ensured by electronic speed control systems or by closed-loop systems controlled by an automaton.

Given this state of the art, it is apparent that textile machinery for transforming yarn, in particular, requires means allowing perfectly controlled management of speed ratios between movements. Such control must be maintained during starting and stopping phases, especially during a transient phase resulting from a power supply failure. In fact, because one production cycle can last several dozen hours, it is obvious that temporary operation or uncontrolled stoppage may result in an extremely substantial loss of production.

Various technical solutions have been suggested in order to ensure energy is maintained and/or regenerated so as to obtain controlled stoppage of work stations in the event of a power supply failure.

For example, there have been proposals to use an auxiliary power source in the form of a system of batteries in order to supply the necessary energy temporarily. It is nevertheless apparent that these battery-operated systems are very expensive to purchase (a considerable amount of energy needs to be stored), to service (frequent replacement in order to ensure satisfactory reliability) and require complex means of management for battery recharging.

In technical fields other than textiles, auxiliary backup systems based on inertial systems have been suggested, these involve rotational driving by means of an electric motor and a flywheel having a considerable mass. In the event of circuit failures, the motor is used as a generator by recovering energy from the flywheel. Such a solution is apparent, for instance, from the teaching of US Patent 6.023.152. As above, this solution is expensive to purchase given the considerable amount of energy that needs to be stored and it is expensive to service.

Recovery of kinetic energy from devices that rotate at high speed and/or which have a high moment of inertia, such as twist spindles for example and, more generally, any device that is part of the machine, has also been suggested. This energy is used to ensure power is supplied to the drive motor of the devices that advance the yarn in order to maintain a constant rate of twist. The kinetic energy is recovered by forcing, after the circuit failure is

detected, sufficient deceleration to operate the motors of the spindles as a generator and reinjecting current into the common power supply circuit such as, for example, a direct current bus. The excess energy can either be shared with other equipments by connecting the direct current buses or be dissipated by braking resistors for example.

It has been proposed, as emerges, for example, from US Patent 5.113.123, to recover this kinetic energy from rotating devices in combination with an auxiliary battery power supply so that some of the energy is obtained by recovering kinetic energy and some is obtained from the batteries.

Generally speaking, systems that use recovery of kinetic energy from spindles operate with a control device in the form, for instance, of a frequency converter that supplies a number of spindles or there is an individual frequency converter for each of the power spindles. Generally speaking, the power spindle frequency converter(s) is/are subjected to the action of a direct current bus that also powers the frequency converters that control the devices associated with advancing the yarn. In the event of a power supply failure, the system detects a voltage drop on the direct current bus so that the frequency converter(s) switches/switch to energy regeneration mode and maintain(s) the voltage on the direct current bus by recovering kinetic energy stored in the power spindles by forcing deceleration.

In cases where an asynchronous motor is used and even in cases where there is an individual frequency converter for each of the power spindles, each of them decelerates along its own curve which depends on the dispersion of load torques. The deceleration set point can, if applicable, be

imposed in a manner that makes it theoretically possible to adjust it in order to maintain the voltage on the direct current bus. In contrast, it is not possible to guarantee correct synchronism given the fact that the slip of the motor is not known because it varies from one station to another.

This solution does not make it possible to force each spindle to decelerate identically and synchronously.

This description of the prior art shows that the energy that is available at the time of the circuit failure is strongly linked to the initial operating conditions of the machine, especially to the number of spindles that are in service and the nominal speed of the latter and their moment of inertia. Such parameters are highly variable given the fact that a machine may operate with a partial or limited number of spindles or at relatively low spindle speeds. The energy required for other movements is relatively insensitive to these parameters so that the deceleration profile making it possible to recover the necessary energy for these other movements depends closely on initial operating conditions. In order to obtain such energy, it is necessary, for instance, to force more rapid deceleration as the number of spindles decreases.

The invention has set itself the object of overcoming these drawbacks in a simple, dependable, effective and efficient manner.

The problem which the invention aims to solve is to obtain synchronism between various movements, especially the movement of advancing the yarn and movements that impart twisting, for example, in a perfectly controlled constant manner throughout the power supply failure by using a system that offers high reliability at reasonable cost.

Faced with the problem that is to be solved, a device has been designed and developed for managing an electrical power failure which has an especially advantageous application in the case of a yarn transformation textile machine in particular, comprising:

- means for advancing the yarns subjected to the action of motor devices controlled by frequency converters or changers supplied by a common direct current bus;
- a monitoring/control system (for example an automaton) supplied by the same direct current bus;
- means for processing the yarns provided in the form of power spindles, particularly spindles subjected to the action of individual motor devices controlled by frequency converters or changers.

Given the problem to be solved, according to the invention, the device comprises:

- a flywheel that is subjected to the action of a motor device controlled by a frequency converter or changer connected to the direct current bus;
- power spindle frequency converters or changers each including means of autonomous stopping in the event of a general power supply failure capable of triggering deceleration according to a pre-programmed built-in ramp function;
- means of monitoring the general power supply capable of forcing all said frequency converters (of power spindles and for controlling the devices for advancing the yarn) to switch to stop mode in the event of a circuit failure so that:
    * each frequency converter brakes the power spindle with which it is associated in accordance with the pre-programmed deceleration ramp

function and is self-powered by the kinetic energy of said power spindle;

* the frequency converter that controls the motor device of the flywheel forces deceleration which sets said motor to generator mode in order to maintain the voltage level on the common direct current bus;
* the monitoring system applies to said frequency converters that control the devices for advancing the yarn, a predetermined deceleration ramp function established with respect to the pre-programmed deceleration ramp function in the spindle frequency converter(s) in order to maintain the correct speed ratios.

In one alternative form of the invention, predetermined deceleration ramp functions can be programmed in the frequency converters that control the devices for advancing the yarn.

As a result of these features, in the event of a power supply failure, a device that monitors the supply voltage instructs the device to switch to energy regeneration mode. The frequency converters of the power spindles independently brake the spindles in accordance with a predetermined curve by dissipating excess energy whereas the frequency converters that control the devices for advancing the yarn apply a deceleration curve that precisely follows the spindles. The flywheel associated with its frequency converter makes it possible, throughout the duration of the stoppage, to power the means of monitoring and controlling and the frequency converters or changers that maintain the voltage level on the direct current bus.

This results in identical stopping from one station to another by creating a permanent energy reserve at low cost in terms of hardware, power consumption and maintenance.

According to other aspects, the pre-programmed ramp functions in the individual frequency converters of the spindles and those programmed in the monitoring system are determined so that, when the stop cycle is triggered simultaneously, speeds remain substantially proportional throughout the duration of the stoppage.

The mass of the flywheel and its speed are determined so that said flywheel contains sufficient energy to maintain the power supply to the means for advancing the yarns throughout the duration of the stoppage.

The invention is explained below in greater detail with the aid of Figure 1 in the accompanying drawing which provides a schematic view showing the management and monitoring device in a yarn transformation textile machine. This diagram and the configuration of the machine are given nearly by way of example and are not limitative.

Each of the twist spindles (1a), (1b), (1c) is driven by an individual control motor (2a), (2b), (2c). Facing each of the spindles (1a), (1b), (1c) there are delivery devices (4a), (4b), (4c) mounted on a common shaft (3) driven by a motor (8a).

Each station is associated with a yarn guide (5a, 5b, 5c) that makes a reciprocal movement and is driven by a motor (8b).

Tension cylinders (7a), (7b), (7c) mounted on a shaft (6) driven by a motor (8c) are installed relative to yarn guides (5a), (5b), (5c). Motors (8a),

(8b) and (8c) are controlled by frequency converters or changers (12a), (12b) and (12c).

Frequency converters (12a), (12b) and (12c) as well as a monitoring system (19) in the form of an automaton, for example, are powered by a common direct current bus (17). A frequency converter (15) that powers a motor (14) connected to a flywheel (13) is also connected to this bus (17).

The individual drive motors (2a), (2b), (2c) of twist spindles (1a), (1b), (1c) are also each controlled by a frequency converter (11a), (11b), (11c). Each frequency converter (11a), (11b), (11c) is equipped with individual means of slaving the speed of the motor to a set point and an individual stop mode in the event of a circuit failure. This stop mode triggers deceleration in accordance with a pre-programmed built-in ramp function. This built-in ramp function is determined to switch the motor to generator mode so that it feeds back energy equal to or greater than that absorbed by the control circuits to the frequency converter. Any excess energy is dissipated by a braking resistor fitted in each frequency converter (11a), (11b), (11c).

The various controlling frequency converters (11a), (11b), (11c) and (12a), (12b), (12c) and (15) are electrically connected to the general power supply denoted by (9) through a three-phase network (16).

In the event of a power supply failure which causes the voltage to fall below a predetermined threshold, means (10) of monitoring the supply voltage order all the frequency converters to switch to stop mode due to a

circuit failure by outputting a command that is transferred, for example, over a data bus (18).

This results in the following sequence:

- Firstly, frequency converters (2a), (2b), (2c) of power spindles (1a), (1b), (1c) switch to stop mode due to a circuit failure; each of them brakes its spindle in accordance with the predetermined deceleration curve by eliminating excess energy through its braking resistor.
- Secondly, frequency converter (15) that controls flywheel (13) forces deceleration that switches motor (14) to generator mode in order to supply the voltage level on direct current bus (17). If necessary, deceleration is continuously recalculated in order to maintain a constant voltage on supply bus (17) to which the monitoring system (automaton) and frequency converters (12a) and (12b) that control the devices for advancing the yarn (4a-5a-7a), (4b-5b-7b), (4c-5c-7c) are connected.
- Finally, the monitoring system (19) applies a predetermined deceleration curve to frequency converters (11a, 11b, 11c), said curve being established relative to the programmed predetermined curve in said frequency converters in order to keep the speed ratios in conformity with the requirements of the process.

The pre-programmed ramp functions in the individual frequency converters of spindles (11a, 11b, 11c) and those programmed in the system for monitoring (19) the devices for advancing the yarns are such that, when the stop cycle is triggered simultaneously, the ratios of the speeds remain correct throughout the duration of the stoppage.

The mass and the initial speed of the flywheel (13) are determined so that they provide sufficient energy to maintain the power supply to the means for advancing the yarns throughout the duration of the stoppage.

When the circuit failure is cleared during the stop cycle, the monitoring device (10) compares either the duration of the failure or a speed (e.g. that of the spindles) to a predetermined programmable threshold.

If the duration is less than this threshold or if the speed exceeds this threshold, the command to switch to regeneration mode is interrupted.

- Frequency converters (11a), (11b), (11c) of power spindles (2a), (2b), (2c) accelerate back up to normal speed in accordance with a pre-programmed curve.
- Frequency converter (15) that controls flywheel (13) accelerates back up to its nominal speed in accordance with a predetermined ramp function.
- Finally, the monitoring system applies a predetermined acceleration curve to the receiving devices which is proportional to the predetermined programmed curve in the spindle frequency converters.

If the duration of the stoppage exceeds this threshold or if the speed at the end of the circuit failure is less than this threshold, the stop cycle is continued until complete stoppage is obtained whilst maintaining synchronism.

The device according to the invention therefore makes it possible to maintain synchronism and correct speed ratios between movements under all circumstances. In the event of a stoppage, deceleration is identical from one station to another because each spindle is driven by its own frequency

converter which includes means of complying with an identical deceleration ramp function until complete stoppage occurs.

The flywheel provides a continuous store of reserve energy used exclusively to supply the necessary energy to control and drive the means for advancing the yarn. The device is therefore of a reasonable size and cost in terms of hardware (frequency converter, motor and flywheel), power consumption (consumption in order to keep the flywheel spinning) and in terms of maintenance (known service life and reliability).

Its advantages are readily apparent from the description, the following features in particular being emphasized and underlined:

- the spindles are not supplied by the common bus but are self-powered and autonomous;
- the set of yarn advancing elements are on the common bus whose supply is maintained by the flywheel so that the two systems are totally electrically independent (only the value of the ramp functions of both avoids any voltage fault).